THE POSTERIOR STAPHYLOMA OF PATHOLOGIC MYOPIA*

BY *Brian J. Curtin,* MD

IN AN EARLIER STUDY OF THE POSTERIOR FUNDUS OF THE MYOPIC EYE, IT WAS FOUND that the prevalence of the posterior staphyloma increased from 1.4% of eyes with axial lengths of 26.5 - 27.4 mm to 71.4% of those measuring 33.5 - 36.6 mm.[1] This same study also showed a significant interrelationship between posterior staphyloma and chorioretinal atrophy with 77.5% of staphylomatous eyes having these degenerative changes. In addition, age was found to be a factor in the production of these lesions which were invariably present in staphylomatous eyes of individuals over 40 years. The impressive prevalence and morbidity of the staphyloma noted were compelling evidence of the need for a more detailed study of these unusual lesions.

Although von Graefe is generally credited with the first study of the posterior staphyloma,[2] his ophthalmoscopic and histopathologic investigation of two eyes did not describe the ophthalmoscopic appearance of the staphyloma so much as the chorioretinal changes which he ascribed to sclerochoroiditis. Von Jaeger's atlas,[3] while frequently noting the condition, does not illustrate it other than to show pallor and tesselation of localized fundus areas in association with crescents of the disc. Even these changes are infrequently pictured in drawings of eyes with posterior staphylomas. It is little wonder, therefore, that a great deal of confusion between crescent and posterior staphyloma is abundant in the older literature. Although a large number of studies have been concerned with staphyloma, these have been essentially case reports and offer little perspective of the subject.

The problem of inadequate appreciation of the types of posterior staphylomas and their prevalence can best be attributed to the previous lack of wide field stereoscopic ophthalmoscopy. Using this examination technique, it was the purpose of this investigation to determine the

*From the Sprague Myopia Clinic of the Manhattan Eye, Ear, and Throat Hospital, New York, New York.

TR. AM. OPHTH. SOC., vol. LXXV, 1977

various morphologic types of posterior staphyloma, their prevalence, and their effect upon visual acuity in a large group of patients. The range of refraction and axial lengths of each type staphyloma were also recorded.

MATERIALS AND METHODS

This study consists of 250 patients who demonstrated posterior staphyloma formation in one or both eyes. There were 114 men and 136 women. They ranged in age from 3 to 86 years. For purposes of analysis, this population was divided into four age groups; the first included those from age 3 to 19 years (69 patients), the second group 20 to 39 years (58

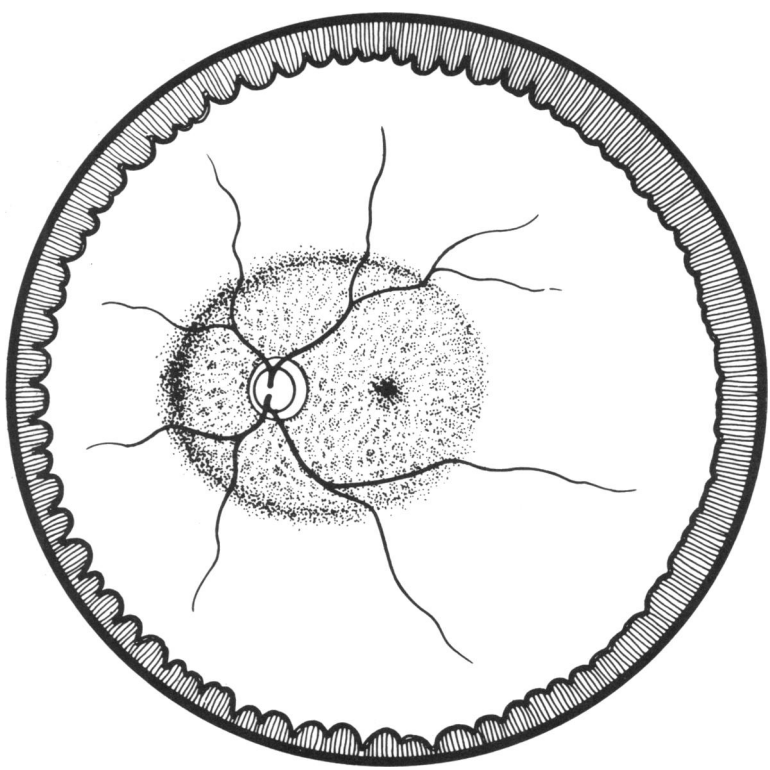

FIGURE 1.
Type I: Posterior Staphyloma.

patients), the third 40 to 59 years (59 patients), and the last 60 to 86 years (64 patients). Thirty-five cases had unilateral staphlomas and 12 eyes could not be included in the analysis because of either total retinal detachment or phthisis bulbi.

All patients had a general ophthalmologic examination including refraction. Fundus drawings were made of each eye under full pupillary dilation using binocular indirect ophthalmoscopy. Condensing lenses of lower powers were found to be of greatest value in detecting shallow staphyloma. Parallactic displacement was also helpful in this regard. A-scan ultrasonic axial length measurements were obtained except in some of the younger patients.

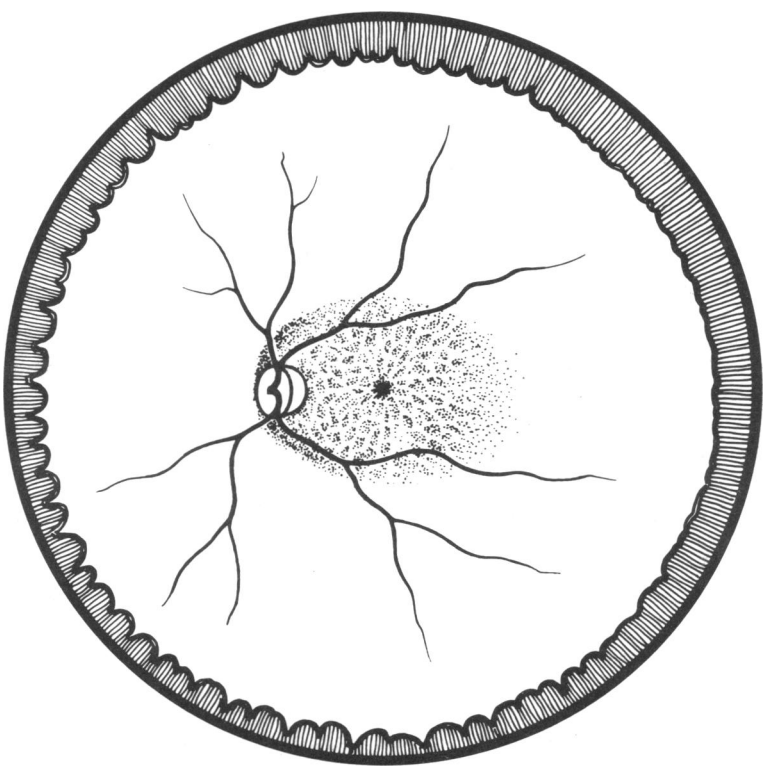

FIGURE 2
Type II: Macular Staphyloma.

RESULTS

STAPHYLOMA MORPHOLOGY

Five varieties of primary posterior staphyloma were encountered in this study (Figs. 1-5). These were classified according to the fundus area in which the ectasia was located. Besides the area of fundus involvement, these staphyloma types differed also in their size, their shape and depth, the abruptness of their margins, and the associated changes in the appearance of the optic nerve and retinal vessels. A comparison of each staphyloma type in regard to these characteristics is found in Table I. The deeper the staphyloma the sharper or more abrupt were its margins. In all instances the ectatic area was seen to have a relative pallor, sometimes of marked degree, in comparison with the uninvolved areas of the

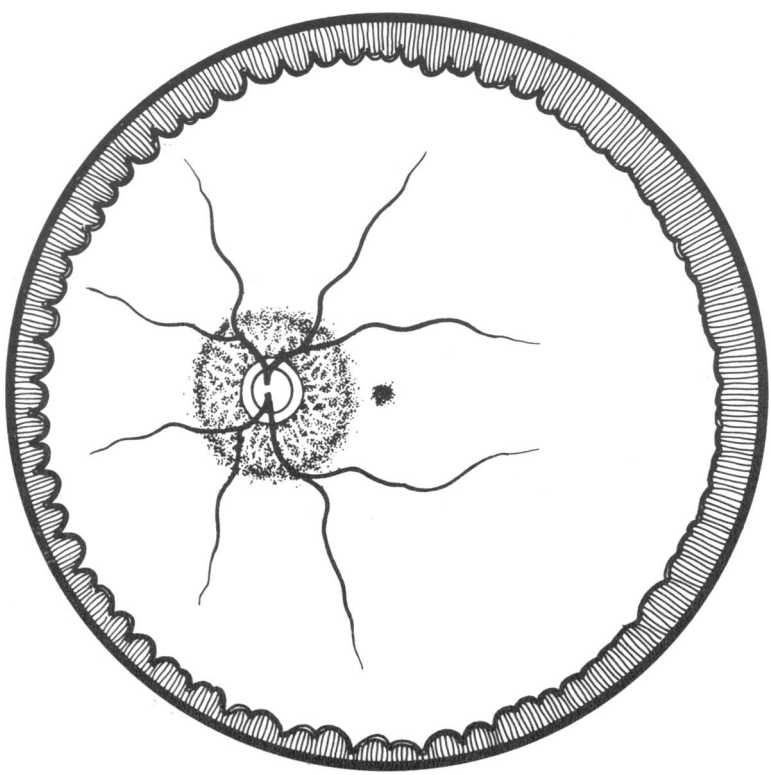

FIGURE 3
Type III: Peripapillary Staphyloma.

fundus. This pallor was combined with an increased visibility of the choroidal vasculature.

Five types of compound staphylomas were also noted. In all but two eyes these were variants of the primary Type I staphyloma. In the first compound staphyloma (Type VI, Fig. 6) there is, in addition to the basic Type I ectasia, a second staphyloma of the macula (Type II). In Type VII staphylomas (Fig. 7) both primary Type I and Type III can be detected. Type VIII is distinguished by the presence of tiers or steps across the wall of a primary Type I staphyloma (Fig. 8). These steps or terraces may be single or multiple and are almost invariably found along the nasal wall of the staphyloma. In the two remaining varieties the large, usually deepened Type I staphyloma is seen to be divided into compartments.

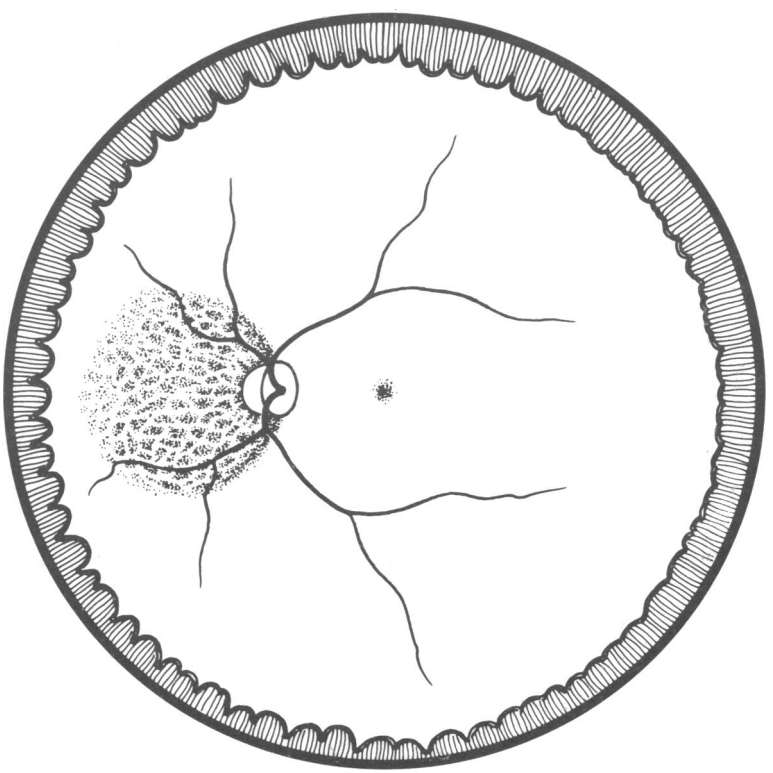

FIGURE 4
Type IV: Nasal Staphyloma.

In the first form (Type IX, Fig. 9) this effect is produced by a vertical septum with a width of from one to two disc diameters which passes from the upper to the lower border of the staphyloma through, or to either side of, the optic nerve. This septum is also ectatic but to a lesser degree. In the presence of extensive peripapillary atrophy it gives rise to a broad light reflex from the bared sclera on indirect ophthalmoscopy. The remaining form of staphyloma, (Type X) is probably the most striking and variable. Here the ectasia is divided into a number of compartments by thin plicae which typically, but not invariably, extend from the optic nerve to the margin of the ectasia (Fig. 10). They may be single or multiple; are themselves ectatic and it is common to find a retinal blood vessel traversing across the top of these folds. The two eyes of this study

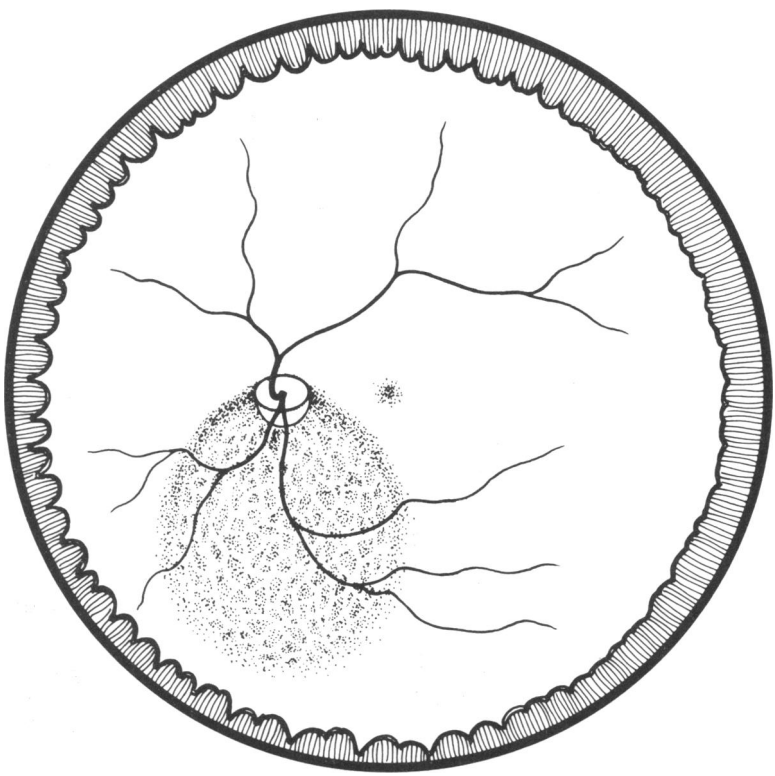

FIGURE 5
Type V: Inferior Staphyloma.

TABLE I: PRIMARY POSTERIOR STAPHYLOMAS

Type Staphyloma	Area of Ectasia	Shape and Depth	Margins	Disc	Retinal Vessels
Type I (Posterior Pole)	From 2-5 DD nasal to optic nerve temporally to macula or several DD temporal to it.	Horizontal oval to almost circular. Variable depth usually increasing with age.	Nasal margin steepest. May be abrupt through 360°. Can be excavated nasally.	Lies flat within ectasia. Temporal crescent with peripapillary extension or peripapillary crescent usual.	Straightened within staphyloma. Often a length of central artery and vein seen lying on disc.
Type II (Macular)	From disc to macula or somewhat beyond; temporal vascular arcades lie on upper and lower walls.	Horizontal oval. Shallow.	Graduated. Steepest at disc.	Tilted temporally with elliptical shape. Temporal crescent. Nasal supertraction may be seen in youth.	Exit disc in temporal direction; nasal vessels curve back.
Type III (Peripapillary)	One to 2½ DD radius about optic nerve.	Circular. May be deep.	Variable, may be sharp throughout 360°. May be excavated occasionally.	Usually lies flat at base of ectasia. May be eccentric. Peripapillary crescent.	Radiate out from disc.
Type IV (Nasal)	Optic nerve nasally for variable distance.	Vertical oval. Shallow.	Graduated. Steepest at disc.	Tilted nasally with elliptical shape. Nasal crescent.	Exit disc in nasal direction. Temporal vessels curve back.
Type V (Inferior)	Optic nerve, or slightly above it, inferiorly for variable distance.	Vertical oval. Shallow.	Graduated. Steepest at disc.	Tilted inferiorly with elliptical shape. Inferior crescent. Superior supertraction rare.	Exit disc in inferior direction. Superior vessels curve back.

with compound staphyloma which did not have a basic Type I staphyloma were plicated forms of a Type IV and Type V staphyloma. The most remarkable staphyloma in this study demonstrated numerous plications so that the large Type I staphyloma was separated into five smaller compartments.

The older literature has taken note of a variety of posterior staphyloma types. In the absence of stereopsis, these were diagnosed by means of parallactic displacement and the presence of arcuate dark lines in the fundus at which point retinal vessels were observed to bend sharply or even disappear behind these shadows. Such lines were usually found on the nasal side of the disc, were concentric with it and the fundus behind them showed pallor, tesselation, and a higher degree of myopic refractive

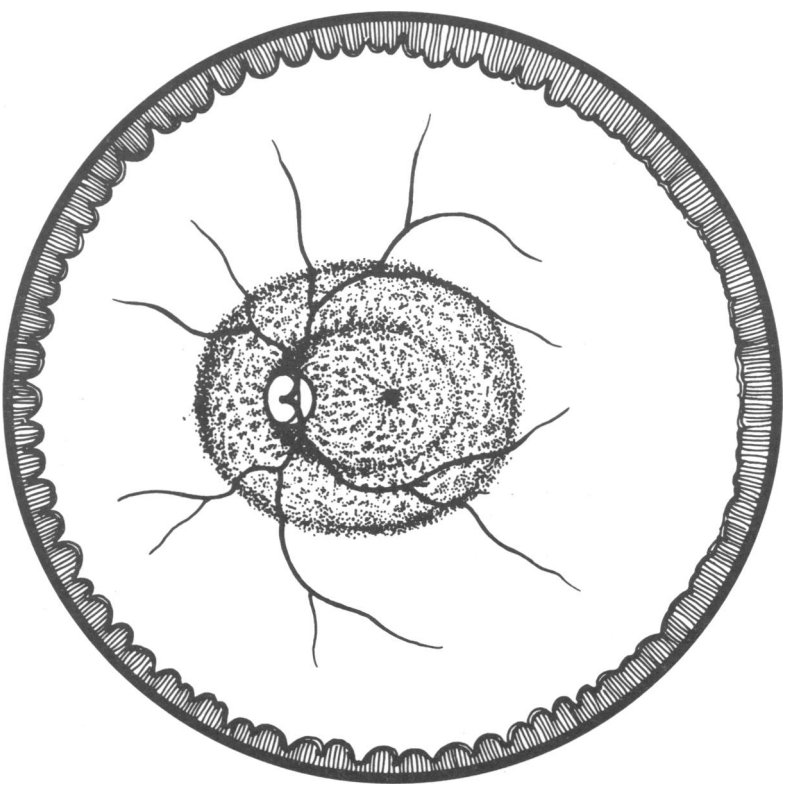

FIGURE 6
Type VI: Combined Staphyloma, Types I and II.

error. The posterior pole staphyloma, Type I, being the most common, has been amply noted in both the older literature[4-8] as well as more recently.[9-11] The nasal ectasia of Type IV has also been the subject of a number of studies[12-15] as has the inferior staphyloma of Type V.[14-16] This latter staphyloma has been regarded as a probable forme fruste of the typical choroidal coloboma.[17] Oddly, the rarest form of primary staphyloma, Type III, has been the subject of a significant number of old as well as very recent case reports.[18-26] At least one variety of the compound staphyloma, Type VIII, has also been recognized.[8,21] The types which appear to have escaped detection are those which are characteristically shallow, such as Types II and VI, or sufficiently complex so that only stereopsis could be expected to provide an adequate means for their

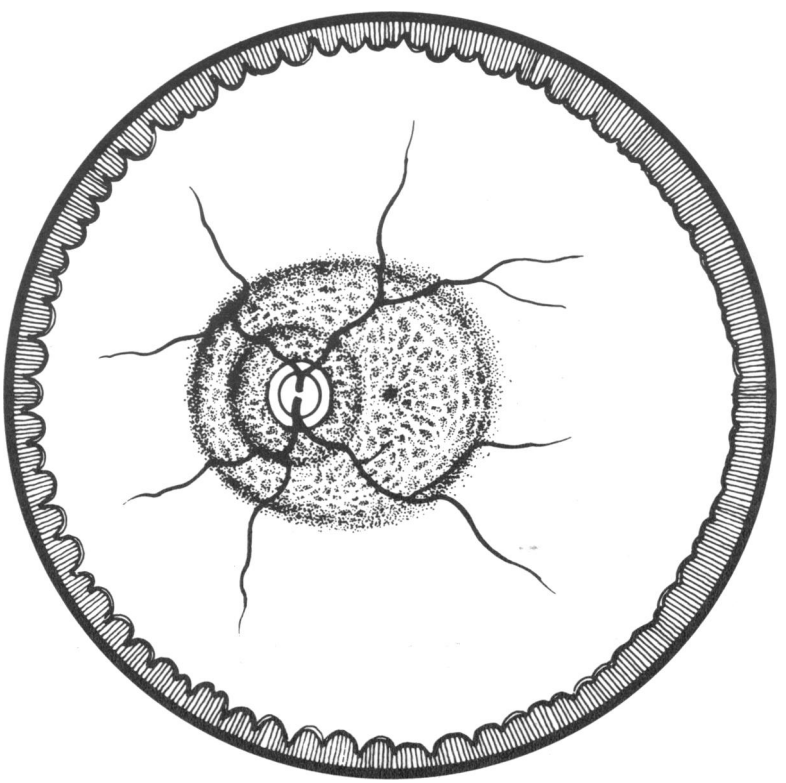

FIGURE 7
Type VII: Combined Staphyloma, Types I and III.

detection. It may be noted here that Thiel's atlas[27] appears to demonstrate a Type VI staphyloma under the title of staphyloma posticum verum. In addition, Knaggs[7] describes what seems to be the juncture of a septum or plica with a Type I staphyloma edge (Case 2:OS). Almost all the previously cited studies are reports of one or several cases and as such, are of limited value in providing an overview of the subject.

PREVALENCE

The frequency of occurrence of each type staphyloma together with the disposition of those eyes without staphyloma are set forth in Table II. It can be readily appreciated from these figures that the posterior pole staphyloma (Type I) is by far the most common of the primary forms

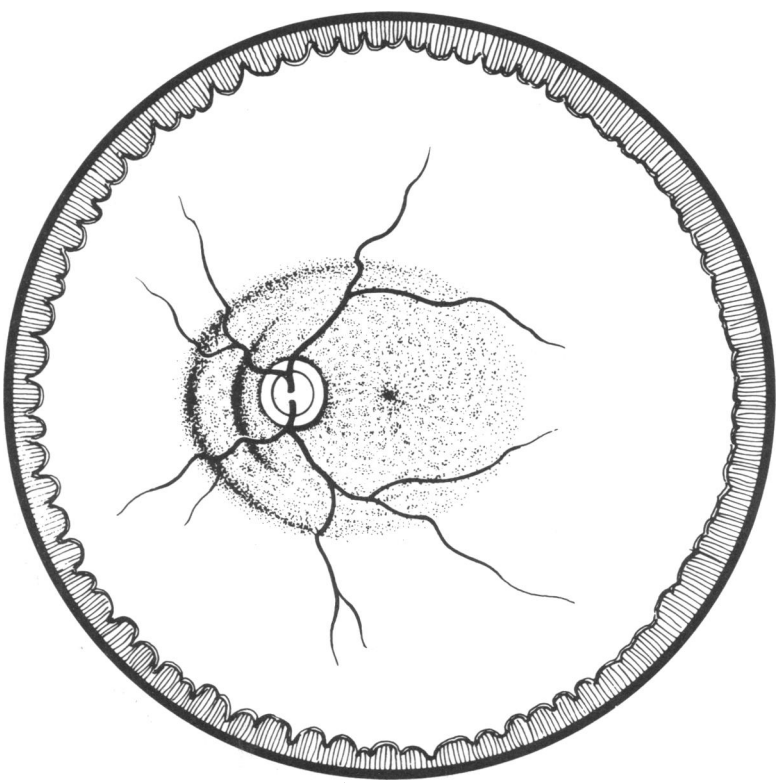

FIGURE 8
Type VIII: Tiered Staphyloma.

(76%). At the same time it is also present as the basic staphyloma in 123 of 125 eyes with compound staphyloma. Peripapillary and inferior staphylomas were the rarest forms encountered. In reviewing each case, a strong tendency towards concordance of staphyloma forms between the eyes could be noted. This was evident with each type of staphyloma. Another important feature is the tendency for these staphyloma to expand and deepen with age. It is unusual to encounter sharp edged staphyloma in the youngest age group for at this time the ectasia is relatively shallow. In the age groups from 20 years and over the staphyloma shows greater depression and the abrupt edge becomes more common. Compound staphylomas, which tend to be deep, are therefore found almost twice as frequently in eyes of patients over 20 as in those below this age.

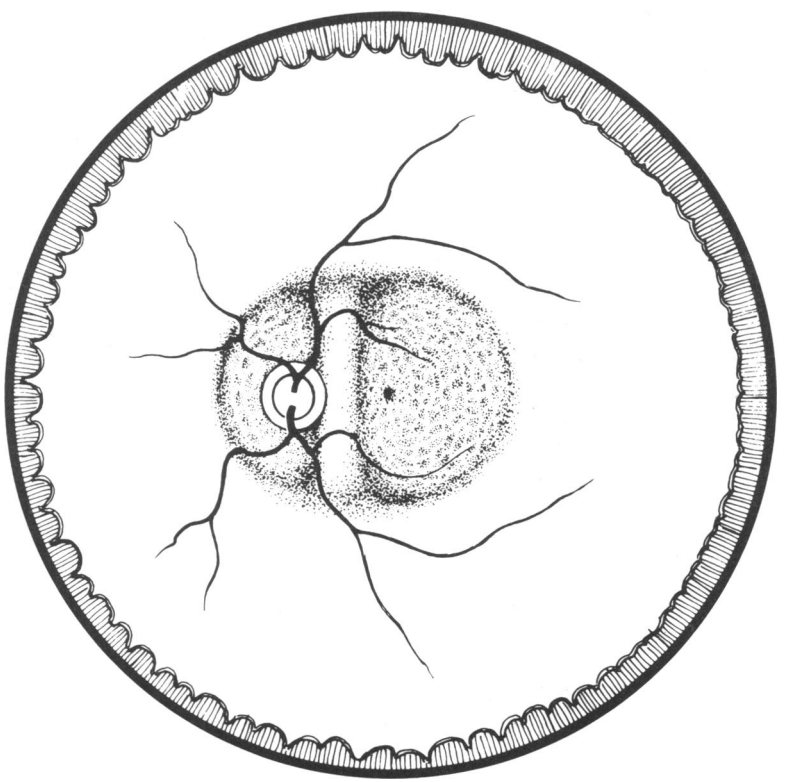

FIGURE 9
Type IX: Septal Staphyloma.

The presence of posterior staphylomas early in life would indicate the essentially congenital nature of this lesion. Type V, as previously indicated, is thought to be related to a defective closure of the fetal fissure. It is probable that defective posterior scleral development and an abnormal collagen restructuring with growth are both factors in the evolution of these lesions.

VISUAL ACUITY

The incidence of blindness (corrected vision of 20/200 or less in the better eye) for each age group is found in Table III. Of the study population, 19.6% were found to be legally blind, the incidence increasing sharply with age. Because pathologic myopia is frequently associated with other

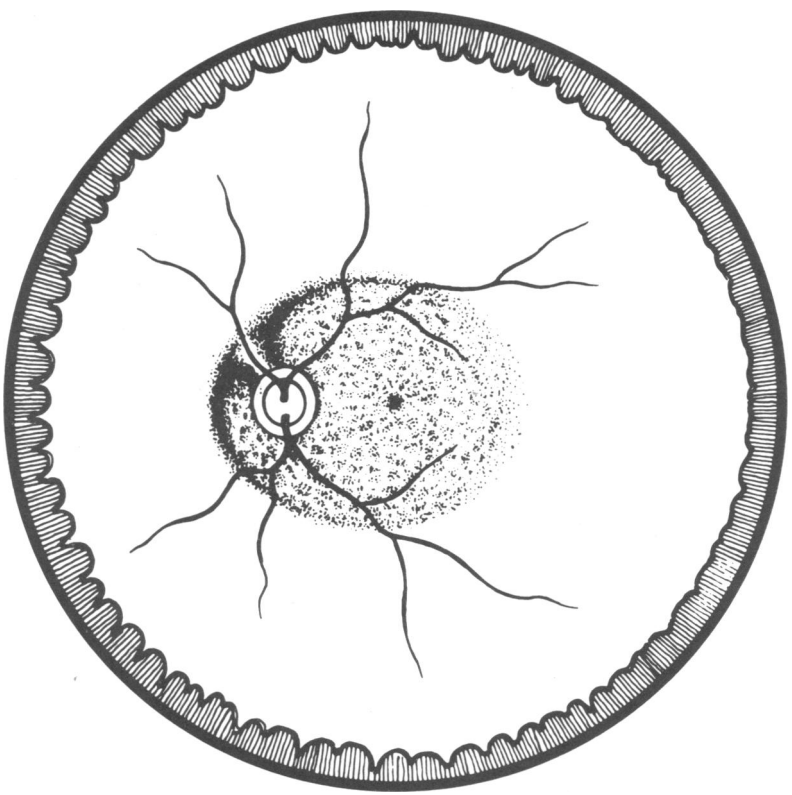

FIGURE 10
Type X: Plicated Staphyloma.

TABLE II: OCULAR FINDINGS AND STAPHYLOMA TYPES: ALL EYES, FOUR AGE GROUPS

	Ages 3-19	Ages 20-39	Ages 40-59	Ages 60-86	Total
Primary Staphyloma Type					
I	65	68	61	55	249
II	28	4	2	4	38
III	2	0	0	5	7
IV	2	2	5	13	22
V	4	0	2	6	12
Compound Staphyloma Type					
VI	8	3	4	3	18
VII	0	0	2	1	3
VIII	6	6	10	7	29
IX	6	11	11	8	36
X	1	10	16	12	39
Without Staphyloma	16	11	1	7	35
Detached Retina	0	1	2	5	8
Phthisis	0	0	2	2	4

ocular disease, a number of eyes had defective vision as a result of such conditions as macular hypoplasia, nystagmus, high astigmatism, cataract, strabismic amblyopia and especially anisometropic amblyopia. Anisometropia in excess of 3 D affected 61 patients (24%) in this series. With the elimination of these eyes, a total of 403 staphylomatous eyes remained. The range and median of visual acuity and the prevalence of blindness for these eyes according to staphyloma type and age can be found in Tables IV and V respectively. The range and median visual acuity of those types with four or less eyes in a category are not recorded because of insufficient data. The most prominent cause of reduced vision was circumscribed chorioretinal degeneration. Rare in the first age group, these lesions became increasingly common so that all eyes were affected in the older age groups. The peripapillary area was most frequently involved. Disciform macular degeneration in the form of the Fuchs' spot was also

TABLE III: PREVALENCE OF LEGAL BLINDNESS IN FOUR AGE GROUPS

3-19 yrs:	5/69 - 7%
20-39 yrs:	5/58 - 9%
40-59 yrs:	17/59 - 29%
60-86 yrs:	22/64 - 34%

TABLE IV: VISUAL ACUITY: 403 STAPHYLOMATOUS EYES
RANGE OF VISION; MEDIAN VISUAL ACUITY
FOUR AGE GROUPS

Staphyloma Type	Ages 3-19	Ages 20-39	Ages 40-59	Ages 60-86
I	20/25 - 20/300 20/50	20/25 - FC 20/70	20/30 - HM 20/100	20/25 - HM 20/200
II	20/25 - 20/200 20/40			
III				20/40 - 20/200 20/200
IV			20/40 - 20/100 20/70	20/40 - HM 20/200
V				
VI	20/40 - 20/70 20/40			
VII				
VIII	20/40 - 20/100 20/60	20/30 - HM 20/50	20/30 - FC 20/80	20/50 - FC 20/80
IX	20/20 - 20/200 20/40	20/25 - 20/200 20/50	20/40 - FC 20/200	20/70 - FC 20/200
X		20/25 - FC 20/200	20/40 - FC 20/100	20/30 - HM 20/300

found to be an important cause of central vision loss. This lesion affected 11% of eyes. The overall prevalence of blindness among the 403 eyes with staphyloma was 34.5%. This increased from a low of 13.2% in the earliest age group to 53.5% in the oldest.

Two points are of interest in regard to these findings. The occurrence of myopic chorioretinal degeneration was found to occur almost invariably

TABLE V: VISUAL ACUITY: 403 STAPHYLOMATOUS EYES
PREVALENCE OF BLINDNESS, FOUR AGE GROUPS

Staphyloma Type	Ages 3-19	Ages 20-39	Ages 40-59	Ages 60-86
I	8/57 = 14%	9/58 = 16%	29/58 = 50%	22/45 = 49%
II	3/23 = 13%	1/1 = 100%	1/2 = 50%	2/4 = 50%
III	1/2 = 50%			4/5 = 80%
IV	0/2 = 0%	1/2 = 50%	0/5 = 0%	7/13 = 54%
V	0/2 = 0%		1/2 = 50%	2/4 = 50%
VI	0/8 = 0%	1/3 = 33%	0/3 = 0%	2/3 = 67%
VII			2/2 = 100%	1/1 = 100%
VIII	0/6 = 0%	1/6 = 17%	3/9 = 33%	2/6 = 33%
IX	1/5 = 20%	3/11 = 27%	7/11 = 64%	3/6 = 50%
X	1/1 = 100%	5/9 = 56%	8/16 = 50%	8/12 = 67%
Total	14/106 = 13.2%	21/90 = 23.3%	51/108 = 47.2%	53/99 = 53.5%

TABLE VI: RANGES OF REFRACTION AND AXIAL LENGTH OF VARIOUS TYPE STAPHYLOMA

Type Staphyloma	Range of Refraction (Spherical Equivalents in Diopters)	Range of Axial Length (In Millimeters)
I	−5.25 to −35.00	25.1 - 38.0
II	−3.25 to −21.00	25.7 - 32.0
III	−10.00 to −16.00	27.5 - 29.3
IV	−4.25 to −20.00	26.2 - 32.5
V	−3.50 to −17.50	26.5 - 33.9
VI	−16.00 to −29.25	26.7 - 34.0
VII	−18.00 to −21.50	28.0 - 32.3
VIII	−11.25 to −28.25	27.6 - 34.0
IX	−10.00 to −27.00	27.5 - 36.0
X	−7.50 to −31.00	28.7 - 35.5

within the staphyloma or near its margins. The typical circumscribed lesions occur predominately with Type I staphylomas and its compound forms but these lesions were also found in the ectatic areas of all varieties of staphyloma. Secondly, the decided tendency towards defective vision in eyes with staphyloma which do not involve the macular area is indicative of the generalized derangement of function of eyes with posterior staphyloma. In one instance, a typical Fuchs' spot occurred in an eye with a Type IV staphyloma and an otherwise normal appearing posterior pole.

REFRACTION RANGE AND AXIAL LENGTH

Table VI includes the range of refractions and axial lengths for each type staphyloma. The unusually wide range of refractions for eyes of the same staphyloma type is remarkable and reaches unusual dimensions. Among the more striking examples of this are Type II with a range of 17.75 diopters, Types VIII and IX; 17 diopters, Type X with 23.50 diopters and, especially, Type I with a range of almost 30 diopters. There is a narrower range for axial length measurements but this is illusory in view of the 1:3 ratio between axial length (mm) and dioptric refraction. The extremes of these measurements include Type VI with a range of 7.3 mm, Type IX a range of 8.5 mm and, again, the greatest range displayed by Type I of almost 13 mm. This phenomenon could also be demonstrated within age groups. For example, in the first age group Type I staphylomas exhibited a refraction range of 29 D and an axial length range of 9.6 mm. In group 2 this staphyloma had ranges of 26 D and 9.4 mm, in group 3, 19.75 D and 10.25 mm and in the oldest group 22.75 D and 9.4 mm. Other types of staphyloma showed substantial ranges for both these measurements but not to this degree.

The wide range of axial lengths and refractions for eyes with the same staphylomas types and within the same age group clearly demonstrate

the problem of using these measurements as a basis for the classification of myopia. Within both these ranges are found both refractions and axial lengths that are quite compatable with the normal eye. Inasmuch as no staphyloma in this study was deeper than 4 to 5 mm, it is apparent that the staphyloma alone cannot account for the bulk of the axial distention of these eyes. This is most evident in the case of such staphylomas as Types III, IV and V. The locations of these ectasias could not significantly affect axial diameter. The principal contribution to the elongation of these globes would appear to be from the equatorial region. This has been demonstrated to be the area that undergoes the greatest distention with the normal postnatal growth of the eye and it has been postulated that overdistention of this area, as in the myopic eye, may be a factor in the production of peripheral chorioretinal pathology.[28,29] One clinical study has shown a direct relationship between the incidence of peripheral retinal degenerations and an increased axial length of the eye.[30] Two separate but related processes would appear, therefore, to be involved in the axial distention of the myopic eye; equatorial expansion and the depth of the posterior staphylomas such as Types I, II and all the compound varieties that involve the posterior pole. Although the second process involves fewer eyes and effects less axial lengthening, it is of greater importance because of its increased threat to central vision, These two distinct processes would also account for those infrequent and unusual cases of high myopia with little or no posterior fundus change and, conversely, those of low myopia with extensive chorioretinal degeneration.

DISCUSSION

The results of this study clearly demonstrate the great importance of the posterior staphyloma. Its presence, in any form, is a basis for the diagnosis of pathologic myopia and no examination of the myopic eye is complete without a careful stereoscopic evaluation of the posterior fundus.

Among the most disturbing findings contained in this work is the increasing incidence of blindness which occurs in these eyes with age. The fact that significant reductions of vision often are seen in the young adult is particularly tragic. The presence of the macular area within the staphyloma is an ominous sign and the prognosis in such cases can, at best, be considered as guarded. The eventual development of chorioretinal atrophy or Fuchs' spots are common in this situation.

The presence of the posterior staphyloma early in life would seem to severly limit any therapeutic approaches to this congenital or neonatal lesion. The findings of this study indicate that there may often be a con-

siderable postnatal development of the posterior staphyloma however. The ectasia appears larger and deeper in the older age groups in association with a greater prevalence of compound types. Although longitudinal studies will be needed to confirm this apparent progression, it may be possible to bring this added ectasia under control by either increasing the resistence of the scleral wall or by reducing the distention force of the eye, the intraocular pressure.

Lastly, the posterior staphyloma may give us an unimpeachable basis for the genetic studies of myopia. It is apparent from the bewildering range of refractions and axial lengths found in this study that these measurements are unreliable indicators of even the very diagnosis of physiologic or pathologic myopia. The morphology of the posterior staphyloma would be a much more reliable basis for genetic studies.

SUMMARY

A total of 250 myopic patients with posterior staphyloma affecting one or both eyes recieved a complete ocular examination including binocular indirect ophthalmoscopy, refraction, and axial length measurement. Ten types of staphyloma were noted; five primary and five compound. The primary staphyloma involved the posterior pole (Type I), macular area (Type II), peripapillary area (Type III), the fundus nasal to the disc (Type IV) and the area below the disc (Type V). Compound staphylomas consisted of combined primary staphylomas or distinctive and complex variations of a primary staphyloma, usually Type I. This type also was found to have the greatest prevalence of all ten types. Patients in this study group had a 19% incidence of legal blindness with 34.5% of staphylomatous eyes having a vision of 20/200 or less. A remarkably wide range of refractions and axial lengths were found for each staphyloma type.

These results indicate the importance of the staphyloma in the diagnosis and prognosis of pathologic myopia. It also offers an improved basis for genetic studies of this disease.

REFERENCES

1. Curtin BJ, Karlin DB: Axial length measurements and fundus changes of the myopic eye. Part 1. The posterior fundus. *Trans Am Opthalmal Soc* 68:312-334, 1970.
2. Von Graefe A: Zwei Sektionsbefunde bei Sclerotico-choroiditis posterior und Bemerkunger uber diese Kramkheit. *Albrecht von Graefes Arch Ophthalmol* 1:390-401, 1854.
3. Von Jaeger E: *Ophthalmoskopischer Hand-Atlas*. Wein, KK Hof-Und Staatsdruckered 1869, pp 192-236.

4. Otto F: Beobachtungen uber hochgradiger Kurzsichtigkeit und ihre operative Behandlung. *Albrecht von Graefes Arch Ophthalmol* 43:323-474, 1897.
5. Weiss L: Ueber das Vorkommen von scharfbegrentzen Ectasien am hinteren Pol bei hochgradiger Myopie. *Arch Augenheilk* 23:194-202, 1891.
6. De Wecker L, Masselon J: *Ophthalmoscopie Clinique*, ed. 2, Paris, Octave Doin, 1891, p 338.
7. Knaggs RL: Symmetrical concentric folds of choroid and retina in four cases of unusually high myopia. *Trans Ophthalmol Soc UK* 22:168-175, 1902.
8. Sattler H: The pathology and treatment of myopia. *Trans Ophthalmol Soc UK* 27:1-26, 1907.
9. Phillips CI, Dobbie JG: Posterior staphyloma and retinal detachment. *Am J Ophthalmol* 55:332-335, 1963.
10. Siam AL: Macular hole with central retinal detachment in high myopia with styphyloma. *Br J Ophthalmol* 53:62-63, 1969.
11. Pemberton JW, Freeman HM, Schepens CL: Familial retinal detachment and the Ehlers-Danlos syndrome. *Arch Ophthalmol* 76:817-824, 1966.
12. Caspar L: Weitere Falle von ophthalmoscopisch sichtbarer Ectasie am hinteren Augenpol bei hochgradiger Myopie. *Arch Augenheilk* 28:75-81, 1894.
13. Ronne H: Konusbildung und excessive Myopie, nasal zur Papille. *Klin Monatsbl Augenheilkd* 57:512-517, 1916.
14. Riise D: Visual field defects in optic disc malformations with ectasia of the fundus. *Acta Ophthalmol (Kbh)* 44:906-918, 1966.
15. Fuchs A: Myopia inversa. *Arch Ophthalmol* 37:722-739, 1947.
16. Masselon J: De la sclerectasie nasale dans la myopie. *Ann Ocul (Paris)* 112:20-29, 1894.
17. Mann I: *Developmental Abnormalities of the Eye*. Ed. 2, Philadelphia, JB Lippincott Co, pp 74,369.
18. Stock W, von Szily A: Eine noch nicht beschriebene kongenitale Anomalie des Augenhintergrundes. *Klin Monatsble Augenheilkd* 44:48-51, (Sec. 1), 1906.
19. Kayser B: Ueber einen Fall von tiefer Ektasie des Fundus am Sehnerveneintritt. *Klin Monatsbl Augenheilkd* 45:76-80, (Sec. 1), 1907.
20. Hancock I: Peripapillary ectasia with inclusion of the optic nerve. *Trans Ophthalmol Soc UK* 27:167-168, 1907.
21. Strebel J: Uber einen Fall vom Typus monolateralis einer Myopia permagna mit sogenanntem Staphyloma verum posticum totale S-Sclerectasia circumscripta postica totalis. *Beit Augenheilkd* 9(84) 305-350, 1913.
22. Young G: Peripapillary ectasia. *Trans Ophthalmol Soc UK* 45:267-273, 1925.
23. Wise JB, Mac Lean AL, Gass DM: Contractile peripapillary staphyloma. *Arch Ophthalmol* 75:626-630, 1965.
24. Sugar HS, Beckman H: Peripapillary staphyloma with respiratory pulsation. *Am J Ophthalmol* 68:895-897, 1969.
25. Caldwell JBH, Sears ML, Gilman M: Bilateral peripapillary staphyloma with normal vision. *Am J Ophthalmol* 71:423-425, 1971.
26. Kral K, Svarc D: Contractile peripapillary staphyloma. *Am J Ophthalmol* 71:1090-1092, 1971.
27. Thiel R: *Atlas of Diseases of the Eye*. Amsterdam, Elsevier Publishing Co., 1963, Vol. 2, p 584.
28. Ts'o MOM, Friedman E: The retinal pigment epithelium III: Growth and Development. *Arch Ophthalmol* 80:214-216, 1968.
29. Streetan BW: Development of the human pigment epithelium and the posterior segment. *Arch Ophthalmol* 81:383-394, 1969.
30. Karlin DB, Curtin BJ: Peripheral chorioretinal lesions and axial length of the myopic eye. *Am J Ophthalmol* 81:625-635, 1976.

DISCUSSION

DR J. WALLACE MCMEEL. It is both a pleasure and challenge to discuss a paper of the fine caliber just presented by Dr Curtin. One can readily speculate on the effort and organization it required. Rather than discuss difficulties associated with surgery on these fragile globes I would like to continue its investigative theme, albeit without its extensive data.

Techniques are now available for study of high myopia in addition to A-scan ultrasonography, routine fundus photography, and large fundus drawings, from which Dr Curtin obtained such worthwhile data. These include fluorescein angiography, wide angle and narrow band fundus photography, B-scan ultrasonography, psychophysical studies, and electrophysical studies. These diagnostic modalities allow one to study aspects of anatomy and nuances of visual dysfunction unavailable until recently. Study of eyes with or without staphylomata may yield abnormal findings.

The wide angle fundus photo allows one to have a panoramic view of the staphyloma complex without the laborious development of a montage from multiple fundus photos. Also, a more accurate assessment of staphyloma depth can be obtained from the wide angle stereoscopic pair than from a stereoscopic montage. Narrow band fundus photography accentuates anatomic subtleties missed by color photography. Fluorescein angiography permits the early discovery of breaks in Bruch's membrane or one of its sequelae, subretinal neovascularization. Ultrasonography is an excellent method for mapping the staphyloma contours, particularly when used in conjunction with wide angle fundus photography. The biometric ruler, an A-scan system with a fixation light, measures the axial length of the eye along its visual axis. A combination of this A-scan and the B-scan afford a significant improvement in the documentation of the anatomic changes in high myopia, with or without staphyloma formation.

Functional changes are present in high myopia, even without staphyloma formation. Electrophysical studies show significantly decreased amplitudes of the ERG. Psychophysical parameters may be variably afffected. The most consistent abnormal finding is an increase in glare sensitivity. Sensitivity to flicker field perimetry may occasionally be reduced.

One patient is presented in whom these studies have been performed. A 19-year-old white man with recent decrease in vision of his right eye was examined. His vision was 20/200 and 20/20 in the left eye. Refractive error: OD $-16.50+1.25 \times 3^\circ$ and OS $-15.00+1.50 \times 50^\circ$. On ophthalmoscopic examination, a small intraretinal hemorrhage was present over the upper portion of the macula in the right eye. Both eyes showed a relatively depigmented fundus often seen in high myopia, with scleral crescents temporal to each disc. B-scan ultrasound showed an elongated eye but no staphyloma, with the antero-posterior diameter being 32 mm CD and 28 mm OS. The fluorescein angiogram revealed a small break in Bruch's membrane, but no subretinal neovascularization. A narrow band photo (645 mm) corroborated this finding. Psychophysical testing showed a glare sensitivity of 22 times normal in the right eye and 9 times normal in the

left eye. The flicker field showed early reduction in sensitivity, as did the dark adaptation curve. The electroretinogram showed significant reduction of response to both photopic and scotopic stimuli.

In summary, a monumental beginning has been made in the study of staphylomata complicating high myopia. With the advent of newer diagnostic techniques, study of the natural course of high myopia, with or without staphylomata, is now worthwhile.

DR ALBERT E. SLOANE. I would like to compliment the speaker for his very enlightening paper and mention two things. In the everyday clinical management of these cases you may not have had the opportunity to do the sort of scientific investigation just described. The first point I would like to make is there has to be a very careful refraction and one must not be afraid to fully correct these children. I have had several instances where children were brought to me at a very young age because they brought objects very close to their eyes in order to see. They were given glasses, which did not help. And a discouraging prognosis was made. One youngster was wearing something like −16.00 lenses and actually he refracted somewhere around 50 diopters and when you consider that wearing these glasses extended his far point by perhaps half an inch you can see he showed good judgment in not wanting to wear glasses. The second point I would like to make is that one cannot judge the vision by the initial glasses given. Even when you fully correct a youngster apparently there is some "clumsiness of the perception" and thus they may show bare 20/400 and a year later they may read 20/70.

DR BRIAN J. CURTIN. I would like to thank Dr McMeel and Dr Sloane for their discussions. From Dr McMeel's remarks it is apparent that the subject of myopia has not been ignored in Boston. The studies he has presented are most thorough. We have also found that B-scan ultrasonography is of great value in the evaluation of posterior staphyloma. It is encouraging to know that a center such as the Retina Foundation and Harvard are actively involved in the study of myopia. Dr Sloane's comments on the marginal level of refraction in highly myopic children is all too true. Rarely does a week go by that we do not see the result of an inept or careless refraction among these children. Certainly there are few patients who are happier with their new lenses than a high myope of any age whose visual rehabilitation has been both complete and comfortable. Thank you very much.